CONTENTS.

PAGE.

Sugar Prices for Month 307

Notes 309

Fertilizer Experiments 310

Sugar Industry in China 312

A Theory of the Extraction of Sugar from Massecuites 313

Sugar Production in the Philippines 336

Commercial Cuba 343

// THE HAWAIIAN PLANTERS' MONTHLY

PUBLISHED FOR THE

HAWAIIAN SUGAR PLANTERS' ASSOCIATION

[Entered at the Post Office at Honolulu, T. H., as Second-class matter.]

VOL. XXVI.] HONOLULU, SEPTEMBER 15, 1907. No. 9.

SUGAR PRICES FOR MONTH ENDING SEPTEMBER 13, 1907.

	Centrifugals.	Beets.
August 16	3,9375¢	9s 9¾d
August 23	3.89¢	10s
August 30	3.905¢	9s 10½d
September 6	3.92¢	10s 3d
September 13	3.95¢	9s 10½d

Messrs. Czarnikow, Macdougall & Co., under date of September 6, report as follows:

The raw sugar market has been at an almost complete standstill since our last report, its monotony of dullness being only broken by a sale of 450 tons Porto Rico Centrifugals and Molasses sugars arrived, the former being taken at 3.92c. and the latter at 3.06c. The Centrifugals show no advance, but the Molasses sugars are .03c. above last sale of same grade.

While this market has been idle, that of Europe has steadily advanced on active buying, as a result of continued unfavorable weather and the fear that even should fine weather now set in, it will come too late to retrieve the ground already lost through an unusually backward season. The last two crops were exceptionally good, and even a normal crop in 1907-8 would have shown poorer results on the acreage planted, but the recent weather conditions point to a yield below normal, and the estimates based on the actual working of the factories, after crop operations begin, are awaited with great interest.

Although our refiners have shown no evidence of being in the slightest degree affected by what is going on in European markets, the case is otherwise as regards sellers of cane sugars, who have felt that the course of events in international markets, which in Beets alone control 55 per cent. of the sugar consumed in statistical countries, justified an advance here, and fully warranted their asking 1/16c. more than they were asking a week ago. Even this moderate demand has not been acceded to and refiners are turning down offers of Cubas at 2.62c. c. f., basis 95°, although on the basis of the landed cost here of Beets, the value of Cubas is 2.81c. c. f. for 96°.

It may be argued that United States refiners need pay no attention to European markets, in a year when they have no occasion to draw upon Europe for Beets, seeing that the quantity drawn by the Atlantic ports from Europe last year (148,000 tons) will be made up by receipts at those ports of 300,000 tons Cane from Java as against 162,000 tons last year.

Whether this expectation of receipts from Java will be fulfilled remains to be seen, for the situation in Europe has already caused fully 25,000 tons Javas originally destined for the Atlantic ports to be diverted to United Kingdom, and New Orleans has taken 12,500 tons. The latter is unlikely to take more, but unless this market responds more freely to prices ruling in Europe, more Javas will undoubtedly go there.

Willett & Gray's Weekly Statistical of September 5, says:

Raws.—It is significant of the general situation for sugar to say that beet sugar was quoted last week at 9s 11¼d and is quoted now at 10s 3d per cwt., 88° analysis, equal to 4.16c. per lb. for 96° test Contrifugals.

Owing to the absence of disposition of refiners here to make offers the quotation for Centrifugals remains the same as asked last week, say 2 9-16c. c. & f. for 95° test Cubas, equal to 3.95c. per lb. duty paid 96° test.

The difference of 24c. per lb. in parity marks the difference of sentiment in the two markets.

In Europe the tone and tendency is towards a constant, steady advance. Here the disposition is to follow Europe as slowly and conservatively as practicable.

This means a forced paying of higher prices for raw sugars in the future, and a corresponding increase in the value of refined. The latter has been neglected too long by many buyers and its consequent dullness keeps our raw market so far below Europe.

Decreased meltings keep stocks at a maximum under continued liberal receipts, so that, as already said, there is no disposition of buyers to purchase other than for anticipated requirements.

Java sugars have moved away from last week's quotation on sale of cargo to Europe at equal to 10s, 7½d. c. i. f., and are now offered at 10s. 9d. c. i. f. 96° test here without buyers, equal to 4.03c. per lb. duty paid.

The news cabled here during the week was unfavorable for growing crops of beets and cane which effected abroad an active speculative demand for contracts at advancing quotations.

It is a long time since the sugar market as a whole has taken on so firm an appearance of stability as now appears.

Receipts for the week were 35,619 tons, melting 36,000 tons; total stock 283,917 tons, against 250,434 tons stock last year.

Quotations for beet futures are 10s. 4d. for January-March, 10s 6¼d. for May.

NOTES.

How Cuban Reciprocity Works.—The round-up of trade with Cuba for the fiscal year ending June 30, 1907, does not show well for the wisdom which opened the door to a market of 85,000,000 consumers, the most liberal on earth, in return for some few extra privileges in a market of less than 2,000,000 of relatively small consumers.

Even as a proposition in philanthropy our reciprocity experiment with Cuba has not been a shining success. Briefly stated, our generosity in allowing the Cubans a rebate of Tariff payments on their exports of sugar, tobacco and a few other things represents a money loss to this country of rather more than $66,000,000 a year.

In 1907 we bought of Cuba products worth $97,441,690, and we sold to Cuba our products of the value of $48,330,913.

The difference between our sales to and our purchases from Cuba was $49,111,777. Close upon $50,000,000 went out of our money supply and was used by Cuba in purchasing from foreign countries commodities which for the most part Cuba could, had she felt so inclined, have bought in the United States.

Then, too, on that nearly $98,000,000 of imports we granted a Tariff rebate of 20 per cent. In this way something like $15,000,000 or $20,000,000 was kept from going into the United States treasury.

Add to the adverse trade balance of nearly $50,000,000 the amount lost in treasury revenue and you have a pretty big total representing the cost of our philanthropical "reciprocity" with Cuba. Somebody is making big money out of the deal, but it is not the United States.

By no means is the Pacific Coast a unit in its desire to exclude Japanese labor. The leading fruit growers of California, through their organization, "The International Equality League of California," have petitioned President Roosevelt demanding the admission of Asiatic labor and enterprise to the Golden Gate State "under no other restrictions than are imposed upon the admission of European labor and enterprise to our Atlantic seaboard." The petition demands the admission to the State of Japanese free labor in order "to save California from the decadence of her industries with reference to the soil."

Australia.—The sugar consumption in the Commonwealth is put down at 187,143 tons, of which Queensland took 27,115 tons. New South Wales was the biggest consumer, 52,589 tons. The average per capita consumption for a series of years was 102 2-5 pounds. The largest relative consumer is Queensland with 114 pounds per head of population, followed by New South Wales with 105 pounds and Western Australia 103 pounds. The imports were 26,099 tons and the exports 11,158 tons. (From the Queenslander.)

AUSTRALIA.—Sugar Statistics. The Customs Department at Melbourne made available details of sugar exportation in Queensland for 1906. In No. 1 district there were 384 white growers and 139 black, in other districts the number were as follows: No. 2, 1352 and 231 respectively; No. 3, 1239 and 65 respectively; No. 4, 837 and 118 respectively. In No. 1, the extreme northern district, black production still exceeded the white population. A total of 30,076 persons were engaged in the industry, namely, white, 23,753, and colored, 6323. This is exclusive of 4294 white persons and 785 colored persons employed in factories. (From the Queenslander, June 29, 1907.)

FERTILIZER EXPERIMENTS.

A recent circular of the Experiment Station of the Hawaiian Sugar Planters' Association by C. F. Eckart, Director of the Division of Agriculture and Chemistry, gives the results of fertilizer tests conducted at substations established on various plantations throughout the group. In 1905 plans were inaugurated for a system of substations for the purpose of conducting agricultural tests with respect to fertilization, cultivation, etc., and also to determine the comparative value of introduced standard canes, and Hawaiian grown seedlings in different localities.

There is probably no cane-growing country where the necessity for substations for experimental purposes is so great as in Hawaii. These Islands present variations of soil, elevation, rainfall and temperature, within the cultivable belt, to a greater extent than obtains in Louisiana or Cuba. These widely varying conditions render it impossible to apply the results determined by the experiments of a single station to any considerable number of plantations.

"During the planting season of 1905 fertilizer experiments were started by the Division of Agriculture and Chemistry on four plantations. These tests were started with the object of ascertaining the fertilizer requirements of cane grown on different soils and under different climatic conditions and of reviewing the data, so obtained, in connection with the composition of the soils as shown by their chemical analysis. It was considered important, owing to the large number of fertilizer recommendations which are continually made by this

Experiment Station and which are based largely upon average weather conditions and analytical results from soil samples, to gauge the reliability of this system in a rigidly practical manner.

"During the past four or five years the question of fertilization has probably received closer and more detailed consideration at the hands of agricultural physicists and chemists in various parts of the world than has characterized the researches along this line from the time of Liebig. New theories with respect to the principles of plant nutrition and the action of fertilizers have been advanced and polemic discussions have evolved a stimulus for increased activity in this important field of investigation which can only have a most salutary effect. While the time is probably remote and may possibly never be realized when the practice of fertilization will become an exact science in the sense that chemistry and physics are exact sciences, it will doubtless in the course of a few years rest upon a securer foundation from the standpoint of economy than it does today.

"In Hawaii it has been amply demonstrated that fertilizers not only pay but pay well when they are judiciously applied and there is little doubt that the quantity and nature of the materials used often control in large measure the crop returns. The fact that the planter may during favorable seasons influence the growth of his cane little or much according to the judgment exercised by him in this particular, should make the subject of fertilization a rich field for careful investigation on every plantation. As much thought should be given the feeding of the cane and the maintenance of soil fertility as is spent in the adjustment of the mill and in the control of the boiling house. For each extra per cent. of sugar won from the cane, twenty per cent. or more may be won from the soil if we can but understand thoroughly the more important principles which underlie the behavior of fertilizers. As a field for profitable research along this line there are few countries if any which offer greater advantages than Hawaii, owing to the radical gains which generally follow fertilization practices. On Hawaiian sugar estates the chief restraining influence on maximum crop production rests with the soil, while in most other sugar growing communities the causes are largely climatic."

In the circular are given the results obtained from the first plant crops harvested from fertilized and unfertilized plats on four experiment fields and the publication of the data at this time is for the sole purpose of showing the progress of the experiments. For reasons which have been clearly set forth in other publications of the Division of Agriculture and Chemistry, no definite conclusions can be reached from an one-crop test, and the tabulated figures, representing yields of cane and sugar, which are presented in the circular will become of value only when they are considered along with those obtained from future harvestings and are not now of general interest. Discrepancies, due to nonuniformity of soil, planting material, and fungus and insect attacks, must be reduced to their possible minimum through the striking of averages and the experiments must therefore extend over a considerable period.

SUGAR INDUSTRY IN CHINA.

It would seem that while enterprising Chinese have succeeded in foreign countries in the sugar industry by utilizing modern machinery and methods, there does not seem to be any disposition on their part to introduce the same methods at home and develop the sugar industry in China where labor is available at a much lower price. Whether this disposition is warranted by the prejudices of the great mass of the Chinese people or the enterprising Chinaman finds it more advantageous to invest his capital and expend his energy abroad, the fact still remains that the Chinese sugar industry must continue to lag and foreign sugar monopolize the Chinese market unless something is done. Commenting on this rather remarkable phase of Chinese industrial life the Swatow correspondent of the North China Daily News says:

"It is a pity that the Chinese will not endeavor to put the sugar industry on a proper basis. Their old obsolete methods are no good in these days of stern competition. Here we have labor plentiful and cheap, but for once that is not all; the cultivation and manufacture on a paying basis of sugar today not only requires cheap labor but also machinery, and that is where the Chinese fail to compete successfully with foreign sugars. Look at the enormous loss of juice every year owing to the obsolete methods of crushing the cane; why in an up-to-date mill the cane comes from the rollers as dry as a bone, but crushed here in the old-fashioned mills at least a quarter of the juice is lost. What is wanted is small steam mills placed in the various districts and for the farmer to sell his cane to the millowners at a fixed price.

"This is the system that has made the cane-growers in New South Wales and Queensland wealthy, and that without cheap labor. There is no district in the world that is more suited for cane-growing than this, with its magnificent rivers and its wonderful irrigation channels and its beautiful soil, and there is no better paying crop. Anyhow the officials are moving in the matter and let us hope something will be done and that soon, and if they'll take a tip from me they will get one of the Chinese who has made a fortune at the game of owning a small crushing steam mill in Australia or elsewhere (and there are a few hundreds of them) to give them a few wrinkles as to how the business is managed, and instead of the farmers losing thousands of dollars as in the past they will be making them."

This would seem to indicate that even China with its cheap labor finds that the sugar industry does not pay when only the crudest methods are employed in its manufacture. The same might be said of all sugar countries in the far east with the exception of the Philippines where labor costs about five times that paid in Java, China or Japan. While China with modern machinery might compete with Java on account of her cheap labor, the Philippines would find it impossible to find a market even should large modern mills be established in the islands on account of the high prices paid for labor.

This leaves China in a position to lead in the sugar industry should the proposed program of the Chinese officials be carried out. The enormous home consumption of China now supplied largely by Java offers all the encouragement necessary for the investment of the capital required to put the industry in China on a paying basis. Chinese labor is the cheapest and best in the world. All things being equal, so far as modern equipment and methods are concerned, the Chinese would have the advantage over any section of the far east in the matter of reliable labor at minimum cost, the most important element in developing a well established sugar industry in this age of keen competition.

---

*A THEORY OF THE EXTRACTION OF SUGAR FROM MASSECUITES.**

By Noël Deerr.

The object of this bulletin is to collect into an accessible form the data requisite for a systematic scheme of sugar boiling and to establish some simple algebraical formulae connecting purity of massecuite and concentration to which it should be boiled to obtain the best results. Incidentally the bearing of these results on the process known as "Crystallization in Motion" and an apparatus known as the "Brasmoscope" are discussed.

At the risk of repeating what is fully known to every one connected with the sugar industry, some fundamental definitions are explained.

* NOTE. Bulletin Experiment Station Hawaiian Sugar Planters' Association.

Solubility. The solubility of a solid in a liquid is a definite constant at any particular temperature, and is independent of any mechanical treatment (stirring or crystallization in motion) that the solution receives. In the appendix is given a table of the solubility of sugar in water at different temperatures.

The solubility of sugar in water is affected by the simultaneous presence of other bodies. In general, the combined effect of the bodies present in cane products is to *decrease* the solubility of sugar and in what may be termed Geerlig's Theory of molasses a definite relation between the relative amounts of organic potassium salts (as indicated by the alkalinity of the soluble ash) and glucose, and the solubility of sugar in exhausted molasses is established for Java molasses; this relation was not found by Mr. S. S. Peck to hold in the case of Hawaiian molasses.

It is certain, however, that certain bodies, of which organic potassium salts are examples are melassigenic, i. e., they increase the solubility of sugar in water. There is also reason to believe that in a sense the solubility of sugar in very impure solution is affected by the viscosity, i. e., if water be continually removed from impure sugar solutions the massecuite eventually becomes so viscous that the sugar molecules have not sufficient freedom of movement to deposit on crystals already formed and (so to speak) remain in solution; actually the sugar is probably present in the solid state but in the form of microscopic or ultra-microscopic crystals.

A saturated solution is one where the dissolving medium (water for example) can dissolve no more of the solid, and consequently if the dissolving medium (water) be removed by evaporation, crystals of the dissolved body (sugar) separate.

A Supersaturated Solution is one where (temporarily) more solid is held in solution than is the case in the final position of equilibrium between solvent and dissolved solid. Such a position can be obtained by the gradual removal of water from a solution of sugar in water; in the change of a material from the dissolved to the solid state a certain resistance has to be overcome, and the change is not instantaneous; from a solution at or near the point of saturation water can be removed faster than the dissolved solid can change its state of aggregation and a state known as supersaturation results. Such a process actually happens in the pan; at graining a supersaturated solution is formed in which suddenly a crop of minute crystals appear. With pure solutions which are not very viscous the supersaturation is very low but as the boiling progresses and more and more sugar is removed from solution a more viscous mother liquor results; the resistance towards crystallization increases and the mother liquor becomes more and more supersaturated; on striking out the contents of the pan *eventually* all the sugar contained in supersaturated solution separates but in general unless the mass is kept stirred the crystals separate out as fine grain in a form not capable of recovery; the craft skill of the sugar maker should be directed towards maintaining the supersaturation in the mother liquor as low as possible, so that as much of the crystallization as possible is done in the pan; if a too high degree of supersaturation be allowed to occur in the pan there is danger of a sudden deposition of crystals in the form of fine or "false" grain; a rapid and complete circulation in the pan whereby crystals already formed are brought frequently into contact with the mother liquor is the cause which, as much as anything, goes to prevent a too high supersaturation.

All low grade strikes when boiled string proof, form supersaturated solutions on cooling from which the sugar separates with extreme slowness, in some cases weeks being taken before grain appears; if such a strike be watched as it cools it will be found that when it reaches the temperature of the air it is extremely viscid and remains so for some time; it is now in a state of supersaturation; suddenly the viscosity becomes much less, the mother liquor becomes liquid and more free, and grain is found to be abundantly present; this change from a viscous supersaturated solution to a free saturated solution and suspended solid often takes place with great suddenness.

Boiling point. All liquids are constantly giving off vapor from their surface and when the pressure of the vapor equals that of the surrounding atmosphere the liquid boils; as the pressure of the surrounding atmosphere increases so does the boiling point of the liquid, and conversely with a fall of pressure there is a corresponding fall in the boiling point; when water or other liquid boils under a pressure less than that normally due to the atmosphere it is said to boil under reduced pressure or less correctly "in vacuo." It is customary to express the pressure under which sugar solutions are boiled in "inches of vacuum." The normal pressure of the atmosphere will support a column of mercury 29.92 inches high; an absolute vacuum would then be expressed as 29.92 inches, and a vacuum of 25 inches will mean that the excess pressure of the atmosphere over the pressure in the vessel, in which there is a vacuum of 25 inches, is $29.92 - 25 = 4.92$ inches. This method of expressing pressure less than one atmosphere is not altogether convenient and for many reasons it would be better to speak of a pan being boiled under a pressure of 5 inches absolute, rather than as under a vacuum of 25 inches. At the end of this bulletin is given a table connecting the temperature and pressure at which water boils, for pressures from 1 inch to 6 inches of mercury or roughly for vacua from 24 inches to 29 inches.

Effect of dissolved solids on the boiling point. The boiling point is increased by the presence of dissolved solids and the following important relation connects boiling point, amount of dissolved solid and pressure under which ebullition occurs. "The elevation of the boiling point due to the dissolved solids is independent of the pressure under which ebullition occurs." For example, under a pressure of one atmosphere water boils at 212 deg. F. and a 75% solution of sugar at 225.2 deg. F. The elevation in the boiling point is then 13.2 deg. F.; under a pressure of 4 inches of mercury (25.9 inches of vacuum) water boils at 125.6 deg. F.; a 75% solution of sugar under the same pressure will then boil at $125.6 + 13.2 = 137.8$ deg. F. The temperatures at which sugar solutions of different concentrations boil under atmospheric pressure have been determined (see table at end); if then the temperature of a boiling sugar solution be known, and also the pressure under which ebullition occurs, then from the elevation of the boiling point over and above the boiling point of water under the same pressure, the amount of sugar in the boiling mass can be at once found. For example, under a pressure of 4 inches of mercury a sugar solution boils at 159.4 deg. F.; water under this pressure boils at 125.6 deg. F.; the elevation in the boiling point then is 29.8 deg. F.; reference to the table of elevation of boiling points of sugar solutions gives the percentage of sugar as 86.25%.

This relation is the basis of an instrument known as a Brasmoscope or Brixometer.

The Brasmoscope. The Brasmoscope was introduced into the beet sugar industry by Curin in 1898 and its form has been modified and its use extended by Claassen.

It consists merely of an accurate thermometer (the bulb of which is immersed in the boiling mass in the pan and placed so as not to be affected by local causes such as the proximity of a steam coil) and an accurate barometer pressure gauge, the ordinary aneroid gauges not being of sufficient accuracy. The form of barometer gauge usually found is a syphon barometer, Fig. 1; this consists of a U tube closed at the end A and open at the end B; the tube is filled with mercury and when held in a vertical position the difference of level between the mercury in the two limbs will give the pressure of the atmosphere in inches of mercury; this U tube is fixed on a board carrying a scale and is adjusted so that the level of mercury in the long limb is at the zero mark when under atmospheric pressure; if the open end be now attached to a vessel in which there is a reduced pressure, the mercury in the long limb will fall until the difference in level is that due to the

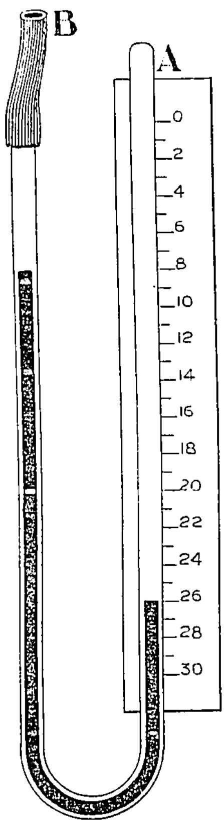

FIG. 1.

pressure in the vessel connected to the short limb; the scale is so graduated as to give directly inches of vacuum in the vessel to which the short limb is attached. This instrument is not too convenient as the gauge has always to be set at the zero mark and as a fall of pressure of, say, 1 inch in the vessel where the pressure is being measured only causes the level of the mercury in the long limb to fall half an inch, the level of the mercury in the short limb at the same time rising half an inch. The writer has devised the pressure gauge described below, Fig. 2.

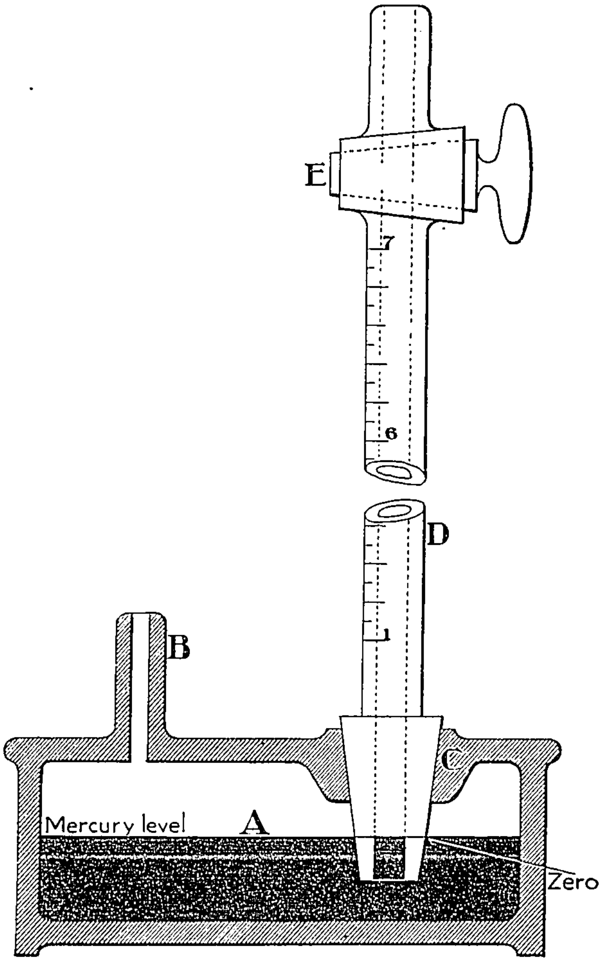

FIG. 2.

A is a shallow receptacle of thick glass partly filled with mercury; on the upper side at B is a tubulure to be connected to the vapor space of the pan by stout rubber tubing; at C is the neck of the receptacle into which fits tightly the barometer tubing D, graduated in tenths of an inch; the receptacle A being filled with mercury the graduated barometer tubing is then inserted in the neck of the flask and mercury is sucked up above the level of the stop cock at E which is then closed; the mercury in A is then adjusted until its level is coincident with the zero mark on D; if then connection be made to the vapor space of a vacuum apparatus by way of B, the height of the column of mercury will directly measure the pressure in the pan.

After the pressure in the pan and the temperature of the boiling mass have been determined by reference to the tables, the elevation of the boiling point is found, and from this the apparent percentage of sugar in the boiling mass is determined.

Instead of using tables, Claassen has devised a mechanical scale for determining the apparent percentage of sugar. In Fig. 3, A, B and C are three scales; A and C are fixed and B is a sliding scale; A is the vacuum scale and C is the temperature scale; C is graduated in equal divisions corresponding to the divisions of a thermometer; on A, opposite to the temperature divisions on C, are marked the corresponding pressures or vacua at which water boils. The sliding scale B is graduated so as to connect the elevation of the boiling point with the amount of sugar present, on the same basis as the divisions in the scale C. A determination is actually made as under (see Fig. 3).

The vacuum in the pan is 28.0 inches and the temperature is 140 deg. F. The zero on the scale B is placed opposite 28.0 on the scale A; the division on the scale C corresponding to a temperature of 140.0 deg. F. is then noted, and opposite this on the scale B is the division 89.9, i. e., the boiling mass contains apparently 89.9% of sugar.

It may at once be stated that it is only bodies in solution that affect the boiling point, and that sugar that has crystallized out has no effect at all; it is only then, with masses boiled string-proof that the apparent sugar percentage of the whole mass is given; in other cases it is the apparent sugar percentage of the mother liquor. The scales in the brasmoscope are calculated on a sugar basis, and give only the apparent percentage of total solids expressed as sugar, exactly as the Brix spindle gives also apparent total solids; actually the non-sugar causes weight for weight a greater elevation of the boiling point than does the sugar, so that the brasmoscope indication will always be higher than the true total solids, and this will be more pronounced the impurer the mass being tested; the error in determining total solids with the Brix spindle also lies in the same direction.

Application of the Brasmoscope. The simplest instance of the use of the brasmoscope lies in its application to low products boiled string-proof; here no sugar separates in the pan as crystals, and the indications of the instrument will now refer to the Brix of the whole mass in the pan. Suppose it has been found by experience that a mass of 50 apparent purity gives the best results when boiled to an apparent Brix, as indicated by the brasmoscope, of 90; when this factor has once been

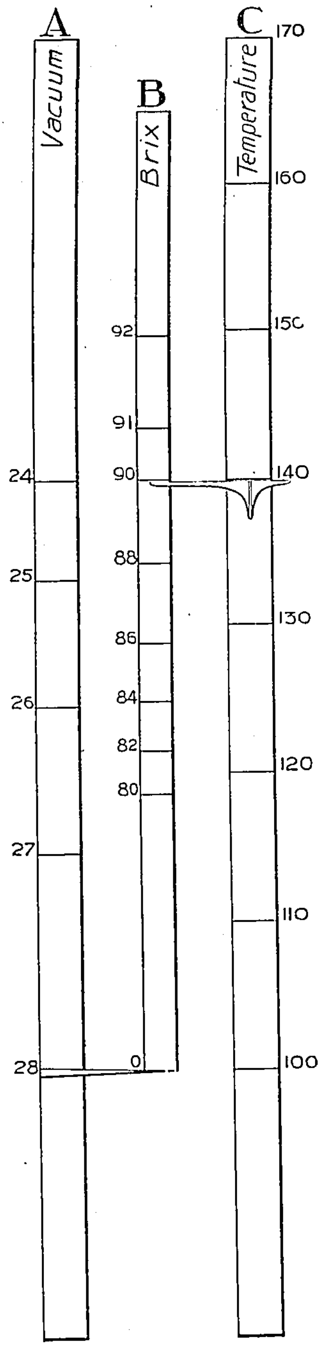
A
Vacuum
24
25
26
27
28
B
Brix
92
91
90
88
86
84
82
80
0
C
Temperature
170
160
150
140
130
120
110
100

FIG. 3.

determined it is an easy matter to boil all subsequent strikes of this purity to the same elevation of the boiling point, and this can, I believe, be done more exactly with the aid of graduated instruments than by the sense of touch of the most experienced sugar maker; the illustration given above demands, of course, that the nature of the non-sugar does not vary and, for one particular factory, I do not think that this assumption is too far from the truth.

Now in actual work the purity of the masses boiled will vary, and to extend the application of the brasmoscope it is necessary to solve the following problem:

"To find the connection between the Brix of a massecuite and the purity of the mother liquor or molasses, the solubility of sugar in the mother liquor being known."

Let x = Brix of the massecuite.
s = solubility of sugar in the mother liquor or molasses.
p = purity of the massecuite.
m = purity of the molasses.

Then $(1-x)$ = water in the massecuite.
$s\ (1-x)$ = sugar in solution, i. e., in the molasses.
$x\ (1-p)$ = total non-sugar or impurities.

(For convenience of calculation these purities are referred to unity instead of to 100 as is usual.)

Then

$$m = \frac{s\ (1-x)}{s\ (1-x)+(1-p)\ x}$$

and

$$x = \frac{s-ms}{s+m-ms-mp}$$

Now, according to Mr. S. S. Peck's analyses of Hawaiian waste molasses, on an average one part of water dissolves 1.78 parts of sugar and the average true purity of the molasses is 45.8. I have then calculated in Table I values of x for purities of the massecuite (p) 46—95; when to s and m are given the values 1.8 and 46; this table gives on the data taken the degree Brix to which a massecuite must be concentrated, so that after complete crystallization the purity of the mother liquor or molasses is 46. Now from the values in the table it is seen that a massecuite of 50 purity will give molasses of 46 purity if concentrated to 80.86 Brix; actually suppose it is found that best results are obtained when the apparent Brix as shown by the brasmoscope is 86.5; it is now desired to find from the formula or table what should be the Brix as indicated by the brasmoscope when the purity of the massecuite is 55. From the formula or table it follows that a massecuite of 50 purity concentrated to 80.86 Brix will give molasses of the same purity as one of 55 when concentrated to 82.44 Brix. The ratio between these two Brix is $82.44 \div 80.86 = 1.0195$. Hence the required Brix as indicated by the brasmoscope is $86.5 \times 1.0195 = 88.19$ i. e., if a massecuite of 50 purity gives molasses of 46 purity when concentrated to 86.5 Brix as indicated by the brasmoscope, a massecuite of 55 purity will give molasses of the same purity when concentrated to 88.19 as indicated by the brasmoscope.

Now, according to the equation, it is possible by boiling to a sufficient concentration to obtain in one process exhausted molasses; thus a syrup of 90 purity if boiled to a concentration of 95.48 Brix would, on the data on which Table I was constructed, give molasses of 46 purity; now from actual experience it is known that with the process commonly followed in these islands that four operations are necessary in general to obtain this end; there is no real disagreement between theory and practice but the causes of this are:

1. It is impossible to practically boil any massecuite to so high a concentration as 95.48; a massecuite so highly concentrated would have no circulation, it would bank up and burn on the coils and it would be a matter of difficulty to remove it from the pans and to manipulate it afterwards.

2. A very supersaturated solution of sugar would be formed in the final stages, from which, under the ordinary process of cooling at rest, sugar would separate with extreme slowness and in a form not suited to be recovered in the centrifugals.

Actually in practice it is known that the higher the purity of the massecuite the higher is the purity of the mother liquor or molasses; this is a natural sequence of the equation and in Table II, I have calculated out values of the purity of the mother liquor or molasses when the purity of the massecuite varies from 75 to 95 and the Brix of the massecuite is constant at 90. This table then connects the purity of the molasses with the purity of the massecuite from which they are derived, provided all the massecuites are boiled to the same degree Brix; actually, however, the higher the purity the higher is the concentration to which the massecuite is boiled.

The amount of sugar then that can be extracted as crystals from a massecuite depends on the degree Brix to which the massecuite can be boiled, or, conversely, to the least possible amount of water which can be left in the massecuite capable of retaining in solution the non-sugar, and it is immaterial, so far as regards the amount of sugar that crystallizes, whether the concentration is done in one or in more operations. This is best shown by a worked out example.

Let there be a syrup of 80 purity, let it be concentrated to a Brix of 90 and let the solubility of sugar in the mother liquor be 2, i. e., for every one part of water in the mother liquor let two parts of sugar be dissolved.

Then the massecuite is of composition

Water	10
Sugar in solution	20
Sugar as crystals	52
Non-sugar	18
	100

Now let the 52 parts sugar as crystals be removed leaving 48 parts of first molasses of percentage composition

Water	20.83	
Sugar	41.66	
Non-sugar	37.50	100
Brix	79.17	
Purity	52.63	

and the sugar removed percent on that originally present is

$$\frac{100 \times 52}{72} = 72.22\%$$

leaving 27.78% in the molasses.

Now let these molasses be concentrated to a second massecuite at 90 Brix and let one part of water hold in solution two parts of sugar.

Then the percentage composition of the second massecuite is

Water	10
Sugar in solution	20
Sugar in crystals	27.367
Non-sugar	42.633
	100.00

Now let 27.367 sugar in crystals be removed. Then per 100 sugar originally present there are removed

$$\frac{27.367}{47.367} \times 27.78 = 16.07\%$$

and the total amount of sugar removed in the two operations per 100 sugar originally present is 72.22+16.07=88.29.

Now to find to what Brix the massecuite must be boiled in one operation so as to leave the same absolute amount of water in the massecuite, we can proceed as follows: In the second massecuite above the non-sugar is 4.2633 times the water and the purity of the original syrup being 80, the sugar in the original massecuite is four times as much as the non-sugar. Let x be the water percentage in the massecuite boiled in one operation so that the absolute amount of water left is the same as that in the two operations above.

Then

$$x + 4.263x + 17.0532x = 100$$
$$x = 4.482$$

The composition of the massecuite boiled to this water content in one operation will be

Water	4.482
Sugar in solution	8.964
Sugar in crystals	67.450
Non-sugar	19.104

and if the 67.450 sugar in crystals be removed, the amount of sugar extracted per 100 sugar in the massecuite is

$$\frac{67.450}{76.414} \times 100 = 88.29\%,$$

the same percentage as was obtained before in two operations.

From what has been already said it follows, that if a massecuite be boiled to a certain preascertained concentration depending on the purity and be allowed to cool, that eventually all the sugar capable of recovery will crystallize out; it does *not* follow, however, that all this sugar will crystallize out in a form capable of collection in the centrifugals or within a reasonable time; in the first place, owing to lack of contact of crystals already formed with any but a small portion of the mother liquor, sugar that crystallizes on cooling will form new fine crystals incapable of recovery in the centrifugals; in the second place, it is known how long it takes low masses to crystallize; the mother liquor of a first massecuite boiled to such a pitch that all the sugar capable of recovery will crystallize is in exactly the same condition as a low grade massecuite, and although in the case of a first massecuite crystallization will be more rapid owing to the presence of crystals already formed, yet a very considerable time will be taken for a complete separation of the sugar from the supersaturated mother liquor; if, however, the massecuite be kept in motion so that the layer or mother liquor in contact with crystals is being constantly renewed deposition will take place much more readily and the sugar separating will deposit on the crystals already formed; this was the original object of the process known as crystallization in motion.

Crystallization in motion originally was applied to first products only; a massecuite was boiled in the usual way to the usual pitch and allowed to cool in motion; this process by allowing sugar held in solution due to high temperature and in supersaturated solution to deposit on crystals already formed gave an increased rendement in first product but in no wise could it obtain a complete desugarization of a pure massecuite unless the concentration was carried to the degree indicated by the formula

$$\frac{s - ms}{s + m - ms - mp}$$

and it has already been noted that so high a concentration is for mechanical reasons impossible. Following on this came the idea of working with masses of purity so reduced by the addition of molasses that on concentration to that water content where all the sugar capable of recovery crystallized, the massecuites were capable of ready manipulation and after cooling in motion on curing gave "first sugar and molasses," i. e., a complete commercial rendement without the interposition of low grade sugars.

A complete crystallization in motion or first-sugar and molasses process may then be defined as "A scheme in which the purity of massecuites are reduced to such a point that they are capable of practical manipulation when concentrated to that point when the water left is only just sufficient to hold in solution the non-sugar, combined with the cooling of the massecuites in motion whereby the deposit of sugar from supersaturated solution is accelerated and takes place on crystals already formed."

The technique of the various processes devised and used to this end may be summarized:

1. A massecuite is boiled from syrup alone and concentrated as far as possible; unexhausted molasses from a previous operation which have been diluted and heated so as to dissolve any fine grain are then taken into the pan, the whole mixed massecuite concentrated to the proper point struck out and cooled in motion.

2. The process is conducted as above save that exhausted molasses are introduced; in this scheme the exhausted molasses should leave the centrifugals on curing at the same purity as that at which they entered the pan; they do not aid in the exhaustion of the syrup massecuite but only act mechanically as a medium in which the crystals swim.

3. The mixture of syrup and molasses is made without the pan, the formation of grain being obtained from syrup alone. As the sugar deposits the purity of the mother liquor decreases and it is the object of the scheme to avoid increasing from time to time the purity of the mother liquor by charging in pure syrup and to regulate the proportions of syrup and molasses charged in as the purity of the mother liquor falls.

4. The Java process which is now used in several factories in these islands and consists essentially of two strikes; the first of fairly high purity, which is cooled in motion for about 12 hours, and the second at a purity of about 60 which is cooled in motion for from 48 to 72 hours and from which exhausted molasses are obtained.

5. The Bock process in which a strike was boiled from

syrup alone and run into crystallizers; about one-third of this strike was left in the crystallizer and on to this was struck a strike boiled from molasses obtained from a previous operation and the whole then cooled in motion.

6. A strike of molasses is boiled string proof and to the concentration required to yield exhausted molasses; into the pan immediately before the completion of the boiling is taken a quantity of sugar which is thoroughly mixed with the contents of the pan, after which the whole is struck out and cooled in motion; the amount of sugar crystals taken into the pan as "priming" is from 25% to 30% of the massecuite.

Whichever one of these schemes be used it is apparent that they all depend for their success upon the control of the water content of the massecuite.

Application of the Brasmoscope to Massecuites Boiled to Grain. The application of the brasmoscope readings to control the water content of massecuites boiled to grain is complicated in that the instrument does not give the Brix of the massecuite as a whole but of that of the mother liquor; what is required to be known may be expressed "What shall be the Brix of the mother liquor in the pan at the moment of observation so that on cooling exhausted molasses result," and algebraically the problem can be solved thus:

Let the solubility of sugar in molasses at a low temperature be s and let it be s' at a more elevated temperature; it is required to find what must be the Brix when the solubility is s' so that the purity is m when the solubility is s. Let x be the Brix of the molasses when the solubility of sugars is s.

Then

$$1-x = \text{water}$$
$$s\ (1-x) = \text{sugar}$$

and

$$m = \frac{s\ (1-x)}{x}$$

whence

$$x = \frac{s}{s+m} \qquad (1)$$

Now let the solubility of sugar change to s' all other factors remaining the same.

The absolute amount of sugar in solution now is $s'\ (1-x)$, the water and non-sugar remaining the same.

If the Brix be now denoted by x',

$$x' = \frac{s'\ (1-x) + \left\{ x-s\ (1-x) \right\}}{s'\ (1-x) + \left\{ x-s\ (1-x) \right\} + 1-x}$$

For s put $s+d$, d being the difference in the solubility of sugar at the two temperatures.

Then

$$x' = \frac{d+x-dx}{1+d-dx}$$

But x has already been shown to be equal to $\frac{s}{m+s}$

Making the substitution

$$x' = \frac{d+\frac{s}{m+s} - \frac{ds}{m+s}}{1+d - \frac{ds}{m+s}} = \frac{s-dm}{s+m-dm} \qquad (2)$$

As a numerical example let the solubility of sugar be 1.8 and let molasses of 46 purity be required; the Brix of these molasses will be from equation (1) $\frac{100 \times 1.8}{1.8+.46} = 79.64$

Now let the solubility of sugar become 2.5 so that d is .7. The Brix of the molasses now is from equation (2)

$$100 \times \frac{2.5-.7 \times .46}{2.5+.46-.7 \times .46} = 82.57$$

Unfortunately the solubility of sugar in the hot mother liquor (s' in the equation established above) in the pan can not be exactly known; it is affected by the temperature prevailing, by the presence of non-sugar and by the degree of supersaturation; now at the temperature 40° C at which it is customary to cure massecuites boiled to grain and cooled in motion the solubility of sugar in water is 2.38 and at the temperature 70° C which is approximately that of the massecuite in the pan the solubility is 3.20; the ratio of these is 1.34; previously I took the solubility of sugar in Hawaiian exhausted molasses as 1.8, that is to say, at the normal temperature here say 27° C; between 27° C and 40° C the solubility of sugar in water increases in the ratio 1.11 and hence at 40° C, I take the solubility of sugar in Hawaiian molasses as $1.11 \times 1.8 = 1.998$ and at 70° C $1.998 \times 1.34 = 2.68$; cutting off the decimals then the values of s and s' in the equation established above will be taken as 2.0 and 2.7.

Now owing to supersaturation the lowest solubility possible in the pan at the temperature of 70° C will be 2.7 and it may be considerably higher; I have then calculated out values of the equation

$$\text{Brix} = \frac{s - md}{s + m - md}$$

for values of $s = 2.0$, $d = 0$ to 1.3 ($s' = 2.7$ to 4.0) and $m = 38$ to 50. These are given in Table III below; in the vertical column on the left hand side are entered the solubilities of sugar in the molasses in the pan; in the horizontal caption are entered the values of m from 38—50; the figure at the intersection of a vertical and horizontal line gives the degree Brix of the molasses in the pan so that when the solubility of sugar becomes 2.0 molasses of the purity in the column selected will result.

Example. The solubility of sugar at the moment of observation is 3.0 and it is desired to obtain molasses of 40 purity when the solubility is 2.0; at the intersection of the line 3 0 and 40 is the figure 84.82, i. e., the Brix of the molasses in the pan must be 84.82

As I pointed out in dealing with the application of the brasmoscope to mass cuites boiled string proof it is impossible to state beforehand what the indication of the brasmoscope should be, and the brasmoscope indications must be systematically compared with the actually recorded results in the factory; when once the brasmoscope indications corresponding to molasses of a satisfactory low purity are obtained then it should be possible to reproduce those conditions more exactly than can be done by the senses of sight and touch.

The process of exhausting rapidly low grade massecuites mentioned above as No. 6 would appear to be a scheme to lend itself readily to a very complete control as it would only be necessary to determine the proper concentration of the low grade massecuite before taking in the sugar used as "priming," as had already been indicated when dealing with the application of the brasmoscope to massecuites boiled string proof; actually I have never seen this scheme worked but I believe it is in considerable vogue in beet sugar factories.

Below I call attention to one or two points of interest not previously mentioned:

1. *Size of crystals.* The rate at which sugar deposits from supersaturated solution is intimately connected with the area of the sides of the crystals which in a given time come in contact with the mother liquor; the smaller the grain the larger is the area of the sides of the crystals and hence desugarization of a supersaturated mother liquor will take place more rapidly with a small grain sugar than with a large one.

2. *Rate of cooling.* As a general rule when a grained massecuite is discharged the supersaturation is relatively high; if

such a massecuite be quickly cooled the deposit of sugar takes place with such suddenness that the sugar now separating from solution does not deposit on the crystals already present but goes to form new crystals; in these islands, I believe, the crystallizing tanks are plain and are not provided with jackets so that means do not exist for controlling the rate at which the massecuite cools; in beet sugar factories, I believe, great attention is paid to this point and it is general to construct crystallizing tanks with jackets into which steam or water may be admitted; the temperature of the massecuite is allowed to fall very slowly at first until (largely aided by the movement of the massecuite) the supersaturation is decreased; after which the rate of cooling is allowed to become more rapid. The rate at which a body cools is, with certain limitations, proportional to the excess temperature and with unjacketed tanks the rate of cooling will be greatest in the earlier stages—precisely the reverse of what is demanded by the above argument.

3. *Remelting low sugars.* When low sugars are remelted the purity of the massecuite is increased and it has already been shown that an increased purity in the massecuite implies an increased purity in the molasses; on these grounds then remelting low sugars is not a process to be recommended and it should rather be the object of the sugar maker to strive to suppress low products altogether rather than to eliminate them by the process of remelting.

SUMMARY.

1. The amount of sugar crystallized depends on the absolute amount of water left in the massecuite.
2. It is immaterial in so far as regards the amount of sugar that crystallizes if the total amount of water evaporated from a syrup be removed in one or in more operations.
3. A certain amount of water has to be left in a massecuite to enable it to be manipulated; with massecuites of high purity to obtain in one boiling all the sugar, that can crystallize, the concentration has to be so high that manipulation becomes impossible.
4. By lowering the purity of massecuites the concentration corresponding to the point at which exhausted molasses result may be obtained the massecuites at the same time being sufficiently fluid to handle.
5. By allowing these massecuites of reduced purity to cool in motion the time taken for sugar to separate from supersaturated solution is diminished and under careful control of the rate of cooling the sugar deposits on the crystals already formed.

6. Systematic observations of the elevation of the boiling point of the mass in the pan form a valuable guide to the operator.

Finally I wish to emphasize that the brasmoscope is not in any way intended to supersede the craft skill of the experienced sugar maker; it is intended to be used rather as an adjunct and a guide and to substitute a definite scientific relation for the varying senses of sight and touch.

TABLE I.

Values of the expression $100 \times \dfrac{s-ms}{s+m-ms-mp}$ for values of s 1.8, and m .46, and of p .46 to .95.

p		p		p	
.46	79.65	.63	85.09	.80	91.35
.47	79.95	.64	85.44	.81	91.75
.48	80.25	.65	85.79	.82	92.15
.49	80.56	.66	86.14	.83	92.55
.50	80.86	.67	86.49	.84	92.96
.51	81.17	.68	86.85	.85	93.37
.52	81.49	.69	87.21	.86	93.79
.53	81.80	.70	87.57	.87	94.20
.54	82.12	.71	87.93	.88	94.62
.55	82.44	.72	88.30	.89	95.05
.56	82.76	.73	88.67	.90	95.48
.57	83.07	.74	89.04	.91	95.92
.58	83.42	.75	89.42	.92	96.35
.58	83.75	.76	89.80	.93	96.79
.60	84.08	.77	90.18	.94	97.24
.61	84.42	.78	90.57	.95	97.69
.62	84.76	.79	90.96		

TABLE II.

Connecting purity of massecuite and purity of resulting molasses when the Brix of the massecuite is constant at 90 and solubility of sugar in molasses is 2.0.

Purity Massecuite	Purity Molasses	Purity Massecuite	Purity Molasses
75	44.44	86	58.82
76	45.45	87	60.60
77	46.51	88	62.50
78	47.62	89	64.51
79	48.78	90	66.67
80	50.00	91	68.96
81	51.28	92	71.43
82	52.63	93	74.07
83	54.06	94	76.92
84	55.55	95	80.00
85	57.14		

TABLE III.

Solubility of Sugar in Pan	Purity of Molasses with Solubility, 2.0												
	38	39	40	41	42	43	44	45	46	47	48	49	50
2.7	84.93	84.65	84.37	84.14	83.48	83.37	83.31	83.05	82.80	82.55	82.30	82.06	81.81
2.8	85.15	84.88	84.62	84.35	84.09	83.83	83.58	83.33	83.09	82.85	82.61	82.37	82.14
2.9	85.37	85.11	84.85	84.59	84.34	84.09	83.85	83.61	83.37	83.13	82.90	82.65	82.46
3.0	85.58	85.33	85.07	84.82	84.58	84.34	84.10	83.87	83.64	83.42	83.19	82.98	82.76
3.1	85.79	85.54	85.29	85.05	84.81	84.58	84.35	84.13	83.91	83.69	83.47	83.26	83.05
3.2	85.99	85.75	85.51	85.27	85.04	84.82	84.60	84.38	84.16	83.95	83.74	83.53	83.33
3.3	86.18	85.95	85.72	85.49	85.26	85.04	84.83	84.62	84.41	84.20	84.00	83.80	83.60
3.4	86.37	86.14	85.91	85.69	85.47	85.26	85.05	84.85	84.65	84.45	84.25	84.06	83.87
3.5	86.55	86.33	86.11	85.89	85.68	85.48	85.27	85.07	84.88	84.70	84.50	84.31	84.13
3.6	86.73	86.52	86.31	86.09	85.89	85.69	85.49	85.29	85.10	84.92	84.73	84.55	84.37
3.7	86.90	86.69	86.49	86.29	86.09	85.89	85.69	85.50	85.32	85.14	84.97	84.79	84.62
3.8	87.07	86.87	86.67	86.47	86.27	86.08	85.89	85.71	85.53	85.36	85.18	85.02	84.85
3.9	87.24	87.04	86.84	86.65	86.46	86.27	86.09	85.92	85.74	85.57	85.40	85.23	85.07
4.0	87.40	87.20	87.01	86.83	86.64	86.46	86.11	86.11	85.94	85.78	85.61	85.45	85.29

TABLE OF THE BOILING POINTS OF WATER UNDER REDUCED PRESSURE.

Pressure in inches of Mercury	Vacuum in inches of Mercury	Boiling Point F. deg.	Pressure in inches of Mercury	Vacuum in inches of Mercury	Boiling Point F. deg.
1.	28.9	79.6	3.5	26.4	120.8
1.1	28.8	82.5	3.6	26.3	121.8
1.2	28.7	85.2	3.7	26.2	122.8
1.3	28.6	87.7	3.8	26.1	123.8
1.4	28.5	90.0	3.9	26.0	124.7
1.5	28.4	92.2	4.0	25.9	125.6
1.6	28.3	94.2	4.1	25.8	126.6
1.7	28.2	96.2	4.2	25.7	127.5
1.8	28.1	98.1	4.3	25.6	128.3
1.9	28.0	99.8	4.4	25.5	129.2
2.0	27.9	101.5	4.5	25.4	130.0
2.1	27.8	103.1	4.6	25.3	130.8
2.2	27.7	104.7	4.7	25.2	131.6
2.3	27.6	106.2	4.8	25.1	132.4
2.4	27.5	107.6	4.9	25.0	133.2
2.5	27.4	109.0	5.0	24.9	133.9
2.6	27.3	110.4	5.1	24.8	134.7
2.7	27.2	111.7	5.2	24.7	135.4
2.8	27.1	112.9	5.3	24.6	136.2
2.9	27.0	114.7	5.4	24.5	136.9
3.0	26.9	115.3	5.5	24.4	137.6
3.1	26.8	116.4	5.6	24.3	138.3
3.2	26.7	117.6	5.7	24.2	138.9
3.3	26.6	118.7	5.8	24.1	139.6
3.4	26.5	119.8	5.9	24.0	140.3

TABLE OF THE ELEVATION OF THE BOILING POINT OF SUGAR SOLUTIONS.

(Claassen-Frentzel Deutsche Vereinzeitschrift, 1893, p. 267.)

Percent Sugar	Elevation of the boiling point F°	Percent Sugar	Elevation of the boiling point F°
75.	13.2	86.75	31.1
75.5	13.7	87.	31.8
76.	14.2	87.25	32.5
76.5	14.8	87.5	33.2
77.	15.3	87.75	33.9
77.5	15.8	88.	34.6
78.	16.4	88.25	35.3
78.5	16.9	88.5	36.0
79.	17.5	88.75	36.7
79.5	18.0	89.	37.5
80.	18.6	89.25	38.3
80.5	19.3	89.5	39.1
81.	19.9	89.75	39.9
81.5	20.5	90.	40.7
82.	21.2	90.25	41.5
82.5	22.0	90.5	42.4
83.	22.7	90.75	43.2
83.5	23.6	91.	44.1
84.	24.7	91.25	45.1
84.5	25.7	91.5	46.3
85.	26.8	91.75	47.7
85.5	27.9	92.	50.2
86.	29.2		
86.25	29.8		
86.5	30.4		

SUGAR PRODUCTION IN THE PHILIPPINES.

(By Sr. Julio de Salutregui, Secretary of the Chamber of Commerce of Iloilo, P. I.)

The cultivation of sugar is, with the exception of Manila hemp, the most important branch of agriculture in the Philippine Archipelago, and until about twenty years ago surpassed even that product in economic value to the islands. Among the various regions in the Philippines that have taken up the cultivation of sugar cane, the most important is the group of islands to the south of Luzon, known as the Visayas, and among these the island which has acquired the greatest prominence in the industry is Negros, which produces more than one-half of the entire amount raised in the Philippines. There are many causes that have contributed to the development of cane raising in the Island of Negros, but the fertility of its soil and its peculiarly suitable climate are undoubtedly the most important. Other factors favoring the development of its agriculture have been the personal security which has existed for a long, long time in this island, and the abundance of labor, as well as the abundance of horses, which are very useful, even at present, to the farmers in the Philippines.

It may be stated that sugar cane is exotic in the Visayas, and although there are no historic data to prove its introduction by the different colonies established on the southwest part of the islands, it is very probable that this plant was introduced by the Chinese who gave a great impulse to its cultivation in the Philippines, as shown by the etymology of the names of the various articles used even now by the Filipinos in the production of sugar, as well as the similarity of the manufacturing process used of old in these islands and in Formosa. It is very likely that the Chinese introduced some of the varieties of sugar cane which were cultivated in Formosa, but even at that time the plant was already known in the Visayas, as well as when the Spanish government imported some of the American varieties. Of all the different kinds of sugar cane produced in the Philippines, the purple variety is the one most generally cultivated at present in the Visayas, either because it is better adapted to this soil, or because it produces the largest amount of sugar.

The methods of cultivation used by the great majority of planters in the Philippines are practically the same, but are quite different from those employed in this industry in the nearby island of Java and in the sugar producing regions of America. Philippine methods are, as a rule, antiquated, almost prehistoric, both in regard to the cultivation of the cane and in the manufacturing process. The industry may be said to be in its infancy in the Philippines, as the planter has not even succeeded in becoming independent and has to be both farmer and manufacturer. There is not a single sugar factory in the entire region of the Visayas; that is to say, a central factory provided with modern and improved machinery, and therefore each farmer has to turn the cane into sugar by his own labor, which explains the poor condition of the sugar industry in the country. When the Americans took possession of the Philippine Islands it was thought at first that the farming industry would be greatly improved by the introduction of new methods and improved machinery for the cultivation of the cane and the production of sugar, and also that some central factories would be built and various small plantations united; but, unfortunately, up to this time, the Americans have done absolutely nothing for the betterment of the sugar industry, either by furnishing industrial, intellectual, or monetary elements, or by helping the planter directly or indirectly. In view of the fact that the insular government has taken no interest whatever in the colonization of and the gradual restoration of agriculture in the entire Philippine archipelago, the United States government has decided to guarantee an interest of four per cent. to the Agricultural Bank, which is about to be established in this colony. Owing, however, to the small capital of $10,000,000, in Philippine money, with which the bank will be started, and to the strict laws prevailing in regard to loans on agricultural property, it is hardly to be expected that this bank will be a very important factor in the development of sugar production in the islands.

The soil most generally suitable for the cultivation of sugar cane is to be found on the high very gradual inclination, having a sufficient amount of moisture with good drainage, and free from vegetation or roots of other plants. The planting season extends from November to January, when the danger from typhoons or storms is over. The cane reaches its complete development in twelve to fourteen months on a good soil, whereas it takes from fifteen to eighteen months on virgin and other lands which have not been thoroughly tilled.

There are very few plantations that will produce five crops in succession from shoots, but on a very good soil it is possible, and even common, to obtain four crops from a single planting. In the majority of cases the planting is done by means of cuttings, using for the purpose the parts of the cane containing less sugar. The result of this practice is that the growth of the cane is stunted and the plants degenerate rapidly. The average production in the Philippines from land properly tilled, according to Philippine methods, is from one to one and a half tons of sugar per acre, which is the smallest average in the entire world, both for cane and for beet sugar.

The operation of cutting and carting the cane is done by means of animal power, as there are very few plantations having railroad tracks for the transportation of the cane to the mill. When a part of the cane has been stored in the shed of the mill, the operation of grinding begins and is carried on from one to three months, according to the amount of cane collected and the interference from rains.

The grinding process used in the Visaya Islands is not only very slow but highly wasteful to the planter, as it leaves in the cane from 30 to 35 per cent. of the juice, which has to be evaporated in order to use the bagasse for fuel when dry. The boiling is done in pans in the open air, and the waste by this process is as large or even larger than that from the grinding. A complete ignorance of chemistry on the part of the farmer is another cause of the poor quality of the sugar produced in the Philippine Islands. It may be said that in the entire region of the Visayas there is not one chemical laboratory in which the most simple operation pertaining to this industry could be performed in a scientific manner. In regard to the study and the analysis of the soil used for the cultivation of cane, and for experiments with new systems of cultivation, the same conditions prevail.

When the sugar that has been boiled in the open pans thickens and cools it is packed in bags made from the leaves of the plant called guri. These bags contain from 80 to 100 pounds of cane each, and when filled they are reinforced with reeds and then they are ready for shipping to the market of Iloilo on launches carrying from 1,000 to 2,000 bags per trip. Merchants in Iloilo classify the sugar according to quality, making it No. 1, 2 and 3, damp and ordinary. This classification is made in the rule-of-thumb way, inasmuch as No. 1 shows 87 degrees on the polariscope, and it is very seldom that one can see No. 0 sugar showing a polarization of over 92 degrees, and the merchant mixes a very small amount of the latter with No. 1 for the adjustment of prices. Prices are as a rule quoted on assorted sugar, the type for which refers to a certain amount of sugar that is formed from the three first qualities on conventional proportions. The unit of weight used for all sugar transactions in the Philippines is the "pico," equal to 137½ pounds.

In Iloilo, which is the main sugar center in the Visaya Islands, are the merchants to whom the planters sell their sugar, either for local consumption or for export. The exporting firms are mainly Chinese or English, whereas the merchants who buy from the planters and sell to the exporters are Spaniards or Filipinos. Sugar plantations are as a rule managed by Spaniards, most of whom come from the northern provinces. There has always been a very close relation between the merchants of Iloilo and the farmers of the Visayas. Three firms have especially distinguished themselves by the interest they have taken in the development of the agricultural industry at all times and circumstances—the old English firm of Loney & Co., the American firm of Russell & Sturgis, and the Spanish house of Inchausti & Co.

The best year known for the sugar industry in the Visaya Islands was undoubtedly that of 1892, which in the port of Iloilo alone the exports amounted to 2,600,000 picos, whereas in the year 1900 they hardly reached 500,000 picos. The change of ownership of the islands, the emigration of capitalists, the damages caused by the last insurrection, and the mortality of cattle were the main causes for this enormous decrease in the production of sugar. As peace is re-established and personal security becomes assured, work on the farms, which had been abandoned by their owners, is being started again, so that in the year 1905 the entire crop of sugar in the Visayas amounted to 1,140,000 picos, and during the season of 1906 it rose to 1,718,000 picos. The coming crop of 1907 is estimated at about 1,600,000 picos, that is 100,000 tons, notwithstanding that many plantations were devastated by locusts and the scarcity of cattle for tilling the land and other farming operations. Up to about ten years ago sugar from the Visayas was exported mainly to England and the United States, but since the Americans took possession of the islands, China and Japan are the best markets for the sale of this article. For instance, in the year 1892 there were exported from Iloilo over 2,000,000 picos for the United States and the British Islands, whereas to China the exports were hardly one-fourth of that amount. On the other hand, in the year 1901 exports to China were ten times larger than the exports to the British Islands and the United States. The exports of sugar to England have ceased entirely because the market of Hongkong pays better prices and therefore many Chinese and English firms have taken up the export to the latter country. Japan is taking gradually increasing amounts, but its importance in the market of Iloilo is as yet only secondary. The United States, which ten years ago was such a good market for the sale of this sugar, does not offer, at present, any margin of profit on account of its high duties, which makes it impossible for us to compete with the sugar from other markets. This, notwithstanding, in the year 1906, we exported to the United States over 180,000 picos, against 1,500,000, which were exported to China and Japan. If the tariff is removed in behalf of the Philippine planter it is to be hoped that the exportation of the main product of the Visaya Islands to the United States will increase very rapidly.

With the construction of railroads in the Visayas a rapid development is to be expected in the sugar industry of the Panay and Negros Islands, as they will open to cultivation all the virgin and waste lands of that region, as up to this time the cultivation has been limited to those lands that are near the coast or navigable rivers, owing to the lack of means of transportation for the product of other sections. The port of Iloilo, where vast improvements are now being made, will derive great benefit from the construction of the railroads and it is to be expected that in about ten years its exports of sugar will be doubled if peace continues and any favorable laws are enacted. The American government would be entitled to the everlasting gratitude of the inhabitants of the Philippine Islands by repealing the part of the tariff affecting the importation of sugar from these islands. The repeal of this part of the tariff has been discussed a number of times in the United States Congress, but the proposition has always met with the argument that if Philippine sugar were to be admitted free of duty in the country, the domestic similar industry would be ruined. Nothing could be more fallacious than this theory. In olden times when the production of sugar used to cost $1.50 per pico of 122½ pounds, the Philippine sugar was exported in large amounts to North America and there is no record in its industrial history of any damage caused by this importation to the domestic industries. If competition from this source was not so injurious when the islands could produce their sugar at such small cost, there is no reason why any harm should come today when the production of sugar in the Philippine Islands costs more than double. The scarcity of competent labor in this line of agriculture, the antiquated methods employed by planters, and the shortage of cattle, and of monetary resources, all combine to prevent any advancement in this important industry of the archipelago. Once that the money in circulation has increased, the mortality of cattle ceased, and the Filipinos become convinced of the advantages of depending on their honest work for a living, the production of sugar will become a prosperous industry, inasmuch as the Visayas are wonderfully favored by natural conditions both in regard to the climate of this tropical region, the fertility of the soil, and the geographical position of the islands.—Dun's International Review.

SUGAR AND MOLASSES AS PRODUCERS OF ENERGY.

(Translated for The Louisiana Planter from La Sucrerie Indigene.)

The feeding of men and animals becomes more and more a science and is subjected to severe laws and to strict rules. Numerous practical experiments have been made during the last twenty years in feeding animals with food materials possessing a maximum of energy with a minimum of cost. By considering these data it was that the Paris Stage Company since 1879 has carefully studied methods for the rational utilization of feed based on its nutritive value. These experiments, inaugurated by Mr. Grandeau, have placed in evidence through his communications made at the last International Health Food Conference, the important role of sugar foods; raw sugar added successively to hay, to maize, or to nitrogenous foods, such as brewery and distilled grains, dried meats, molasses mixed with starchy food, with turf, straw, grape pulp or beet chips.

The rational feed of the horses of this great company necessitated the consideration of the prices of the staple and perhaps because of the unfortunately low price of sugar, a preference was given to this food. Anyway, all the experiments made at the research laboratory of this company confirmed the general tendency to increase the ration of the horse with sugar to replace the other hydro-carbons. It was the chief result of the light thrown by these laboratory studies that they confirmed fully the announcement made in 1882 by Messrs. Grandeau and Leclerc that nitrogenous materials were not the generating elements of mechanical work. Other important points were brought out and especially the role played by the amids and particularly of molasses and of sugar foods. At last a new experiment proof determined the role of sugar and of molasses as producers of energy.

The splendid experiments of Mr. Chauveau have brought definitely to light the importance of the energy of sugar. Some new confirmations of this fact have been given by Mr. Lefevre, of the University, who has been able to undergo enormous fatigue in mountain climbing by the means of lacto-vegetable food, of which 250 grams of a total of 3,700 grams were sugar and 1,200 grams were milk. The rest was composed of cheese and fruits. The total calorific value of this food was 6,600 calories, of which 1,000 was from the sugar. The liquids necessary were furnished exclusively by water, five to six quarts, which does not indicate that the sale of wines must cease.

Among the recent experiments made to determine the energy value of sugar we may cite those of Rubner and of Atwater. These biologists found that there are fats which evolve great energy, their calorific value being 9.3 calories (Rubner) and 8.93 calories (Atwater). The carbohydrates have respectively 4.1 (Rubner) and 4.03 (Atwater). These figures are thus seen to agree. If we consider the table of dynamic equivalents, that is the food weights that could be substituted of one kind for another that would give the organism the same energy, we find that 100 grams of animal fat correspond to 235 grams of sugar, to 235 grams of meat, to 228 grams of starchy material, to 255 grams of glucose, to 214 grams of casein. However, these figures give absolutely no information on the qualitative comparison of various food stuffs. They only give the numerical equivalents.

Mr. Chauveau found that muscle which worked consumed only the glucose or the glycogene carried by the blood circulation. From this the energetic value of a food should not be measured according to its calorific power, that is to say, not by the number of calories produced by its combustion in a calorimeter, but rather by its yield in glucose. Here the saccharose and starchy materials take the first rank. Chauveau has calculated the isoglucosic equivalents corresponding to 100 grams of fat and that result one would compare with the equivalent of Rubner cited above 100 fat corresponding to 153 grams of sugar, 161 grams of glucose and 146 grams of starch.

Lefevre has essayed to reconcile these two theories that diverge somewhat. He conceded readily, admitting that an organism which labors and which receives the fat transforms this fat into glucose in absorbing 334 calories per 100 grams of fat and in forming 161 grams of glucose. This quantity of glucose will give 480 calories by the combustion in the muscle and there will remain 120 calories for the energy and the work, a total of 934 calories. If one gives to the organism glucose exclusively, all the calories will pass into work, since they will not have to undergo the preparatory transformation. Lefevre concludes that fat is a source of heat and sugar a source of work.

Other conclusions might be drawn from the works of Lefevre relative to the digestibility, that is to say, digestive utilization of the various foods. Among them sugar holds the first rank, being equal or superior to 96 per cent., and then white bread, rice and mashed potatoes. Eggs and meat occupy the sixth or seventh rank and milk the eighth.

All these conclusions are very interesting. They fix in a manner absolutely scientific the basis of feeding in general and the great value of sugar. The practical conclusion which can only give excellent results will be the taking into account and determining the rations of soldiers and horses in the army. There the old errors still continue and very often the men and the animals are fed, if not insufficiently, at least in a manner scarcely hygienic. If we follow our ordinary tastes we do not deceive ourselves.

COMMERCIAL CUBA.

PROSPERITY OF THE ISLAND DISCLOSED BY TRADE STATISTICS.

Consul-General James L. Rodgers, of Habana, sends the following résumé of the commerce and industries of the Cuban Republic for the year ended December 31, 1906:

The trade of Cuba in the year 1906 up to the period of internal difficulties, which resulted in American intervention in September, had never been better, even when the low price of sugars was taken into account. The acreage of both cane and tobacco had been increased, general agriculture was expanding, the use of American goods of all kinds was increasing, and preparations were being made to develop trade and commerce in numerous ways. Into this condition came the chill of impending civil war, with its usual deterrent effect on trade. However, the rapidity of the change from the constitutional to the provisional government left but little time for the full development of evil effect upon commerce, and therefore there is comparatively little evidence of the same. There had been also but few natural causes for a poor financial year, and therefore the result can be attributed to the natural expansion of the country's interests. For even if the apparent volume of trade was smaller, the gain was large in those things which produce future benefits. The result of the year as compared with 1905 is expressed in the following official table, the values being in American money:

Country	Imports		Exports	
	1905.	1906.	1905.	1906.
United States	$43,118,040	$37,602,345	$95,330,475	$88,175,456
Germany	5,915,920	6,402,793	3;905,471	3,671,194
Spain	10,179,558	9,018,121	786,344	676,620
France	5,242,901	5,572,799	1,198,652	1,513,125
United Kingdom	13,508,273	14,081,023	5,795,350	5,899,734
Other American countries	12,515,591	10,985,927	1,747,568	2,467,078
Other European countries	3;601,220	3,376,016	770,358	768,655
All other countries	890,015	979,597	633,266	742,674
Total	94,971,518	98 019,621	110,167,484	103·914,336

The loss in exportations, $6,252,948, or 6.01 per cent., as compared with the year 1905, is attributed to the low price of sugar, while the gain in importations, $3,048,103, or 3.10 per cent., is the direct result of the progression expressed by new machinery, material, equipment, and supplies brought in largely from the United States.

TRAFFIC WITH UNITED STATES.

Of the total importations, the United States furnished 45 per cent. in 1905 and 48 per cent. in 1906, while of the total exportations the United States took 86 per cent. in 1905 and 84 per cent. in 1906. The following table, showing the constantly increasing trade between the United States and Cuba, is from an unofficial Cuban source, but is apparently correct:

Year.	Imports.	Exports.	Year.	Imports.	Exports.
1890	$13,329,493	$54,628,710	1904	$32,644,345	$74,950,992
1900	26,934,524	31,747,229	1905	44,569,812	95,330,475
1902	23,061,623	48,619,588	1906	47,602,345	88,175,451
1903	23,504,417	57,228,291			

[The value of the imports from Cuba, as given by the Bureau of Statistics, for the fiscal year ending June 30, 1907, was $97,441,690, and of the exports thereto, $49,305,274. —B. of M.]

The total Cuban customs revenue for 1906 was $25,090,084, and for 1905, $25,258,005, a decrease of $167,921, which can be attributed to the falling off in the value of sugar exportation. The great increase in the value of the Cuban trade in late years has come from the augmentation of her natural industries, such as raw sugar, which in 1905 accounted for over 60 per cent. of the export values; tobacco and manufactures thereof, which provided 26 per cent.; and agriculture, including fruit production, which made up perhaps 8 per cent. more. The importation account has been swelled by such articles as iron and steel products, machinery of various kinds, provisions, and many other staples, which all express the effort of new capital entering a country in which material progress and increase in laboring population has begun. Manufacturing for export and local consumption, while of small moment in the past, is also beginning to develop and with good promise of success.

SIGNS OF FUTURE ACTIVITY.

Although the year 1906 does not show it in volume, the effect of American intervention and the program of internal improvement inaugurated thereunder will be plainly visible in the 1907 statistics and in those of the fiscal year 1906-7. Under the promises of stability in present and future afforded by the American provisional government an era of marked improvement of private property immediately set in, this being evidenced in new machinery for sugar plants, extension of railways in city and country, increase of stocks in mercantile establishments, establishment of ranches, creation of orchards, and in additions to farm equipment. And perhaps greater than all was the importation of road-making equipment, this being the result of the announced intention of expending sums aggregating $13,000,000 upon the public highways. The effect of all this is being shown day by day in Cuba, and perhaps never before has a more promising future been apparent. Of the trade of the Republic, the United States has naturally the lion's share, and it can be added to proportionately if there is a close observance of Cuban demands in trade, by which is meant giving just as good packing, as good credits, and as good, if not better, values than any other country.

For the first six months of 1907 the duties collected at the custom house of the port of Habana were $9,831,698, as compared with $9,668,009 for the similar period of 1906, in which there were no such events as a changed government, strikes at ports of destination of vessels, a practically complete suspension of the manufacture of cigars, and various other untoward incidents.

Sugar Plantations, Cane Growers and Sugar Mills.

ISLAND AND NAME.		MANAGER.	POSTOFFICE.
OAHU.			
Apokaa Sugar Co	*	G. F. Renton	Ewa
Ewa Plantation Co	*	G. F. Renton	Ewa
Wainae Co	***	Fred Meyer	Waianae
Waialua Agricultural Co	*	W. W. Goodale	Waialua
Kahuku Plantation Co	x*	Andrew Adams	Kahuku
Waimanalo Sugar Co	**	G. Chalmers	Waimanalo
Oahu Sugar Co	x	E. K. Bull	Waipahu
Honolulu Plantation Co	**	J. A. Low	Aiea
Laie Plantation	x*	S. E. Wooley	Laie
MAUI.			
Olowalu Co	**	Geo. Gibb	Lahaina
Pioneer Mill Co	x	L. Barkhausen	Lahaina
Wailuku Sugar Co	**x	C. B. Wells	Wailuku
Hawaiian Commercial & Sugar Co	x*	H. P. Baldwin	Puunene
Maui Agricultural Co	...	H. A. Baldwin	Paia
Kipahulu Sugar Co	x	A. Gross	Kipahulu
Kihei Plantation Co	x*	James Scott	Kihei
HAWAII.			
Paauhau Sugar Plantation Co	**	James Gibb	Hamakua
Hamakua Mill Co	*x	A. Lidgate	Paauilo
Kukaiau Plantation	x	J. M. Horner	Kukaiau
Kukaiau Mill Co	*x	E. Madden	Paauilo
Ookala Sugar Co	**x	W. G. Walker	Ookala
Laupahoehoe Sugar Co	*x	C. McLennan	Papaaloa
Hakalau Plantation	**	J. M. Ross	Hakalau
Honomu Sugar Co	**x	Wm. Pullar	Honomu
Pepeekeo Sugar Co	**x	Jas. Webster	Pepeekeo
Onomea Sugar Co	**x	J. T. Moir	Hilo
Hilo Sugar Co	**	J. A. Scott	Hilo
Hawaii Mill Co	x	W. H. Campbell	Hilo
Waiakea Mill Co	*x	C. C. Kennedy	Hilo
Hawaiian Agricultural Co	**x	Wm. G. Ogg	Pahala
Hutchinson Sugar Plantation Co	**	Carl Wolters	Naalehu
Union Mill Co	*x	H. H. Renton	Kohala
Kohala Sugar Co	*	E. E. Olding	Kohala
Pacific Sugar Mill	x**	D. Forbes	Kukuihaele
Honokaa Sugar Co	x**	K. S. Gjerdrum	Honokaa
Olaa Sugar Co	xx	J. Watt	Olaa
Puna Sugar Co	...		Kapoho
Halawa Plantation	x*x	T. S. Kay	Kohala
Hawi Mill & Plantation	††	John Hind	Kohala
Puako Plantation	††	Jno. C. Searle	S. Kohala
Niuli Sugar Mill and Plantation	*x	Robt. Hall	Kohala
Puakea Plantation	*x	H. R. Bryant	Kohala
KAUAI.			
Kilauea Sugar Plantation Co	**	Frank Scott	Kilauea
Gay & Robinson	x*x	Gay & Robinson	Makaweli
Makee Sugar Co	...	G. H. Fairchild	Kealia
Grove Farm Plantation	x	Ed. Broadbent	Lihue
Lihue Plantation Co	x	F. Weber	Lihue
Koloa Sugar Co	x	P. McLane	Koloa
McBryde Sugar Co	*x	W. Stodart	Eleele
Hawaiian Sugar Co	x*	B. D. Baldwin	Makaweli
Waimea Sugar Mill Co	*	J. Fassoth	Waimea
Kekaha Sugar Co	x	H. P. Faye	Kekaha

KEY.	HONOLULU AGENTS.	
*	Castle & Cooke	( )
**	W. G. Irwin & Co	(8)
***	J. M. Dowsett	(1)
x	H. Hackfeld & Co	(9)
*x	T. H. Davies & Co	(8)
**x	C. Brewer & Co	(6)
x*	Alexander & Baldwin	(6)
x**	F. A. Schaefer & Co	(2)
x*x	H. Waterhouse Trust Co	(2)
††	Hind, Rolph & Co	(2)
xx	Bishop & Co	(1)